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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 237.

B. T. GALLOWAY, *Chief of Bureau.*

GRAIN-SORGHUM PRODUCTION IN THE SAN ANTONIO REGION OF TEXAS.

BY

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AND

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ISSUED JANUARY 31, 1912.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 13, 1911.

Sir: I have the honor to transmit herewith a paper entitled "Grain-Sorghum Production in the San Antonio Region of Texas," by Carleton R. Ball, Agronomist in Charge of Grain-Sorghum and Broom-Corn Investigations, and Stephen H. Hastings, Superintendent of the San Antonio Experiment Farm, and recommend that it be published as Bulletin No. 237 of the series of this Bureau. This paper embodies the results of experiments conducted cooperatively by the Office of Grain Investigations and the Office of Western Agricultural Extension.

The grain sorghums are excellently adapted for profitable use in this region except for the injury now known to be caused by a minute insect, the sorghum midge (*Contarinia* (*Diplosis*) *sorghicola* Coq.). The attacks of this parasite result in a failure to set seed, a condition commonly known as "blast." It has been popularly supposed to be due to the washing away of the pollen by heavy rains during the blooming period. This paper describes the experiments which resulted in the discovery that the trouble was due to the midge, discusses the attempts to find resistant varieties of sorghum, and finally presents the experimental proof that midge evasion is possible through early planting. Profitable yields have been obtained from a number of varieties by planting late in February or early in March.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—710.

GRAIN-SORGHUM PRODUCTION IN THE SAN ANTONIO REGION OF TEXAS

INTRODUCTION.

One of the most serious agricultural problems of the San Antonio region has been to find a reliable grain crop, especially for feeding purposes. All of the small grains are so seriously damaged by rust that their production is usually not profitable, even with the relatively high prices which prevail in this section. Yields of oats obtained in experiments carried on for a series of years have been altogether too small to be profitable. Corn, also, has been a precarious crop and is not looked upon favorably by many farmers in this region. When the yields of a series of years are considered, it is scarcely a profitable crop, in spite of the fact that occasional years occur in which the yields are high. Consequently an altogether too high percentage of the grain fed by farmers and practically all of the grain consumed in the city of San Antonio has to be obtained from other regions.

Sorghums are well known to be more drought resistant than other grain crops of the San Antonio district. For this reason the profitable growing of these crops is of the greatest importance to farmers in this section of the State. Sorghum for forage, when grown so that cultivation is possible, has proved one of the most remunerative crops. While it is not so resistant to long periods of drought as cotton, it has been fully as profitable, if not more so, than cotton, because it matures earlier in the season, thus often evading the droughts that occur frequently during the late summer months. The grain sorghums have the same desirable qualities as the saccharine sorghums or sorgos so largely grown for forage.

It is not the intention of the writers to discourage the growing of other grain crops in areas having conditions different from those where these experiments were conducted. It is well known that a few miles in either direction make a very material difference in the prevailing agricultural crops grown in southern Texas. Within 30 miles northwest of San Antonio cereals are grown successfully, although the rainfall is only slightly higher than it is at San Antonio.

This is largely due to the higher altitudes. South of San Antonio the junior writer has observed excellent fields of corn grown without irrigation, and yields have been reported by farmers there which indicate that the growing of the crop in that section is not nearly as precarious as in the vicinity of San Antonio. The higher yield there is no doubt very materially influenced by the soil conditions. The soil is much lighter in character, approaching a sandy-loam type, generally underlain with a clay subsoil, and is consequently able to absorb and retain more of the rain that falls than a soil like that on which the experiment farm is located. The effect of climatic and soil conditions on crop production here is very marked and no general statement governing all localities can be made, even if only a comparatively few miles separate the two points. The local conditions should be carefully studied by the farmer before condemning or adopting a crop.

The grain sorghums, so well adapted to successful cultivation in the southern Great Plains area, have not been largely grown because of their common failure to set grain. This condition, commonly known as "blast," was long held to be due to unfavorable weather conditions, especially to heavy rainfall during flowering time. It is now known to be due to infestation by the sorghum midge.

This paper discusses three series of experiments conducted since 1907, mostly at the San Antonio experiment farm, and the results obtained from them. The object of the first series was to determine why the sorghums failed to set seed and resulted in the discovery of the sorghum midge and much information on its habits and distribution. The second series was an attempt to find midge-resistant varieties and resulted in failure. The third series was conducted to determine whether the midge injury could be avoided through extra early planting and has been completely successful.

CLIMATIC CONDITIONS AT SAN ANTONIO.

A brief review of the climatic features of San Antonio is desirable in order to show the conditions under which these crops must be able to grow. The following data on both climate and soil are taken from a previous publication of this Bureau.[1] The tables have been extended to include 1909, 1910, and so much of the year 1911 as is available.

The average annual rainfall, calculated from the records of the Weather Bureau, beginning with the year 1878, is 28.1 inches, which is about the same as at Lincoln, Nebr., or St. Paul, Minn., but because of the irregularity of its occurrence, the compact character

[1] Headley, Frank B., and Hastings, Stephen H. The Work of the San Antonio Experiment Farm in 1908. Circular 34, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1909.

of the soil (which causes a large loss in surface run-off), and the higher evaporation of the region the effectiveness of the rainfall is lessened, making the country semiarid rather than semihumid, as at Lincoln and St. Paul.

The summers are hot and with a rather dry atmosphere, which condition results in rapid evaporation of moisture from the soil surface and from the leaves of plants. The winters are in the main mild and pleasant, but the rather frequent occurrence of the "northers" during this season often results in hard freezes.

Table I gives the absolute minimum temperatures and the dates of the first and last killing frosts for each year since 1892. The lowest temperature recorded in this period was 4° F. in February, 1899, and killing frosts have been known to occur as late as April, although in the majority of cases the last one was in the month of February.

TABLE I.—*Dates of killing frosts and absolute minimum temperatures at San Antonio, Tex., from 1892 to 1911, inclusive.*

[Compiled from the records of the United States Weather Bureau.]

Year.	Last spring frost.	First autumn frost.	Absolute minimum for the year.	Year.	Last spring frost.	First autumn frost.	Absolute minimum for the year.
			°F.				°F.
1892	Mar. 19	Nov. 18	19	1902	Feb. 16	Dec. 16	26
1893	Feb. 8	Nov. 24	26	1903	Feb. 18	Nov. 18	19
1894	Mar. 26	Nov. 20	16	1904	Feb. 12	Nov. 12	22
1895	Feb. 27	Nov. 27	11	1905	Feb. 21	Dec. 4	13
1896	Feb. 15	Nov. 28	27	1906	Feb. 6	Nov. 20	24
1897	Feb. 1	Dec. 3	18	1907	Feb. 8	Nov. 11	28
1898	Jan. 16	Nov. 22	20	1908	Feb. 20	Nov. 14	22
1899	Feb. 6	Dec. 4	4	1909	Feb. 17	Dec. 9	20
1900	Apr. 12	Nov. 12	19	1910	Feb. 24	Dec. 7	19
1901	Mar. 6	Dec. 10	15	1911	Feb. 23	.....	.....

Table II gives the rainfall for each month in the year for 20 years, beginning with 1891. It will be noted that the monthly rainfall from April to September, inclusive, averages over 2 inches and that in the remaining months from October to March it averages less than 2 inches. If the rainfall each month would regularly approach the mean rainfall for that month, as given in the table, there would be no reason why fair crops should not be raised every year, but the rainfall during the year is so unevenly distributed that the yield of crops for each season is exceedingly variable.

Previous to May, 1901, there were five months and previous to April, 1902, there were six months of drought. The year 1893 was a year of low precipitation, but the distribution was of such a nature as to be favorable to spring crops.

TABLE II.—*Monthly precipitation at San Antonio, Tex., for the years 1891 to 1910, inclusive.*

[Compiled from records of the United States Weather Bureau.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1891....	5.63	1.38	1.18	4.57	2.36	2.16	0.85	1.06	3.60	0.60	0.92	5.73	30.04
1892....	1.51	.71	1.75	.16	.89	3.83	.05	9.09	1.09	1.48	1.09	4.16	25.81
1893....	.11	1.11	2.14	2.18	3.36	1.90	.96	.92	.10	.08	4.62	.76	18.24
1894....	1.42	.52	.80	2.65	1.71	3.09	.60	8.55	1.48	.89	(1)	.04	21.75
1895....	1.24	3.97	2.24	.29	6.66	2.09	1.07	1.90	1.25	1.43	3.38	.55	26.07
1896....	2.90	2.36	.66	2.73	2.74	.61	2.69	2.96	8.87	6.04	.79	.74	34.09
1897....	1.55	.15	1.65	1.84	3.13	2.19	.28	.40	1.61	1.35	.43	1.34	15.92
1898....	.46	1.16	1.47	1.46	1.06	7.06	2.24	3.35	1.32	.03	1.34	1.54	22.49
1899....	.38	.31	(1)	2.60	2.22	4.32	2.85	.00	.57	1.31	1.70	3.39	19.65
1900....	5.42	.34	4.35	9.11	4.47	.78	2.24	4.05	.97	2.94	1.82	.70	37.19
1901....	.41	.71	.54	.39	2.47	1.86	3.79	.96	4.20	.12	.64	.15	16.44
1902....	.70	.55	.12	2.31	3.14	.02	3.85	.00	5.52	2.54	3.53	2.51	24.79
1903....	2.39	7.88	1.29	1.74	1.95	4.75	7.52	.20	2.96	1.61	(1)	.82	33.11
1904....	.30	.64	.16	3.25	5.93	1.73	3.50	1.97	7.74	2.86	.24	1.06	29.38
1905....	.88	1.62	2.74	6.08	4.11	6.01	2.82	.51	1.80	1.83	2.63	1.56	32.59
1906....	.29	1.07	1.29	3.94	.86	.62	4.34	2.25	1.74	1.09	1.33	1.60	20.42
1907....	.80	.78	1.88	3.77	4.64	.18	2.68	.80	1.11	3.54	6.79	.80	27.77
1908....	1.01	2.42	1.31	2.87	6.07	.30	.66	4.27	3.92	1.47	2.61	1.61	28.52
1909....	.10	.71	.88	.82	1.77	1.65	3.27	1.70	.56	1.55	.53	1.38	14.92
1910....	.88	.78	.42	3.31	1.56	.55	1.37	.37	.56	3.35	1.38	1.69	16.22
1911....	.02	1.66	2.72	3.41	2.01	.30	.....	.....	.....	.....	.....	.....	.....
Mean[2]	1.42	1.46	1.34	2.82	3.05	2.29	2.38	2.26	2.55	1.80	1.79	1.60	24.77

[1] Trace.

[2] Excluding the record for part of 1911.

SOIL CONDITIONS OF THE REGION.

San Antonio lies in the southern extension of what is known as the Black Prairie region, or the black lands of Texas, and near the northern edge of an area known geologically as the Rio Grande Plain. The soil is mostly the result of the weathering of limestone rocks of the Upper Cretaceous period. There have been recent alluvial deposits washed down from the higher lands northwest of the city, resulting in local modifications, chiefly through the addition of coarser material. The typical soil is a heavy black or brownish clay or clay loam.

The region around San Antonio has been made the subject of a soil survey by the Bureau of Soils, and twelve soil types have been recognized, of which five are different kinds of clay amounting to 40 per cent of the area, two are clay loam amounting to 27 per cent, three are sandy or silt loam amounting to 20 per cent, and two are sand amounting to 13 per cent.

Analyses made in connection with this soil survey and showing instances where calcium carbonate constitutes more than half the total soil mass are given in Table III.

TABLE III.—*Percentages of lime (calcium carbonate) in soils in the vicinity of San Antonio, Tex., having an unusually large lime content.*

Soil type.	Depth of sample.	$CaCO_3$.
	Inches.	*Per cent.*
Austin fine sandy loam	0–12	47.0
Do	12–40	52.0
Austin clay	0–18	59.8
Do	18–40	73.4
Do	0–18	62.4
Do	18–36	63.1

This lime occurs in the soil both as finely divided material and as gravelly concretions. In the former condition it is generally dark colored through staining by decomposed organic matter, while in the latter condition it is usually white. The concretions are concentrically laminated and are often cemented together by finer material.

FINDING THE CAUSE OF SORGHUM "BLAST."

THE POPULAR THEORY.

The failure of sorghum varieties to produce a full crop of seed has been a matter of common knowledge for many years. The trouble is usually known as "blast" and many scattered references to it may be found in agricultural literature. Several different theories as to the cause of this sterility have been advanced from time to time. Among the agencies that have been regarded as possible causes are fungi, insects, and various weather conditions, such as heavy rainfall, high humidity, severe drought, and hot winds. Among the growers themselves it has been quite generally held that the trouble results from the washing away of the pollen by heavy rains during the blooming period.

Early in 1907 letters were sent by the senior writer to a number of agronomists, botanists, and entomologists in the States affected asking their opinion as to the cause of the trouble. No one professed to know, but the general consensus of their opinions pointed toward the theory of excessive rainfall as the cause. As stated, this was also the theory generally held by the farmers concerned.

PRELIMINARY EXPERIMENTS.

In accordance with the prevalent theory, some experiments were planned by the senior writer in the early spring of 1907 to determine the cause of this sterility. Through the courtesy of Prof. W. R. Dodson, director of the Louisiana experiment stations, and Mr. C. S. Scofield, agriculturist in charge of the Office of Western Agricultural Extension of the Bureau of Plant Industry, arrangements were made

for a series of experiments at the State experiment station at Baton Rouge, La., and the experiment farm at San Antonio, Tex., respectively.

The experiments were designed to permit observations on the effect of all kinds of weather conditions on sorghum varieties in the flowering stage throughout a period of several weeks or even months. The plan was simple. Several different varieties were planted on each of a series of successive dates at each of the two places. This insured that at least one variety, and probably more than one, would be in flower every day for a long period. The effect of every actual weather condition or combination of conditions on the setting of sorghum seed could thus be observed. Full opportunity was also given to observe the attacks of fungous or insect pests throughout the season.

The four varieties chosen for the experiments included two grain sorghums and two sorgos. The two grain sorghums were Blackhull kafir (G. I. No. 185) and Dwarf milo (G. I. No. 186). The two sorgos were Minnesota Amber (S. P. I. No. 20799) and Sourless (S. P. I. No. 17984), a strain of Planter.

First plantings were made at both points about April 15 and regularly every week thereafter until June 10 at San Antonio. At Baton Rouge heavy rains interfered and the second planting was not made until June 14, the third on June 28, and weekly thereafter until early in August. All necessary weather records were kept at both stations from the time that the earliest variety prepared to head.

REDISCOVERY OF THE SORGHUM MIDGE.

After the heading of sorghums in Louisiana and Texas was well begun the senior writer went to the field to take charge of the experiments. Baton Rouge, La., was reached on July 27, 1907, during a period of frequent and heavy showers. The later varieties in the early planting and the earlier varieties in the later planting were in various stages of flowering. It was the intention to devote much time to the study of the effects of the prevailing rainfall and humidity on the fertility of the pollen and receptivity of the stigmas. However, the first examination of heads then in flower disclosed the presence of great numbers of a small fly on or about the flowering spikelets. These flies were found to be mostly females actively engaged in depositing their eggs within the spikelet. Careful scrutiny of more advanced heads discovered larvæ and pupæ within the glumes, while still older heads showed emerging adults or empty pupa cases protruding from the tips of the spikelets. All heads so infested were invariably sterile. This, then, was the probable cause of the sterility of the sorghums.

Reference to entomological literature [1] found a description [2] with brief notes by D. W. Coquillet of a new species of Cecidomyiidæ found in sorghum heads received in 1895 and 1898 from Alabama and eastern Texas, respectively. A comparison of the description of his species with the species in hand showed them to be identical. Coquillet stated that the development of seeds had been prevented by the presence of larvæ of this insect (*Diplosis sorghicola* Coq.) within the spikelet. He noted also the presence of a hymenopterous insect, an undetermined chalcid of the genus Aprostocetus. Such a chalcid, presumably parasitic, was found abundantly with the midge at Baton Rouge. This was later determined by Mr. J. C. Crawford, of the Bureau of Entomology, as also a species of Aprostocetus, but distinct from that found by Coquillet.

Work was at once begun to determine whether this sorghum midge was the cause of the widespread sterility of sorghums. A series of bagging experiments was started to exclude the midge from heads at different stages of their development before, during, and after anthesis. Ordinary paper bags from a grocery store, of a size sufficient to completely envelop a single head, were used, the mouth of the inflated bag being compressed tightly around the peduncle below the head and securely fastened by means of fine copper wire.

After a week spent in these studies the senior writer proceeded to San Antonio, Tex., leaving the work at Baton Rouge in charge of Prof. H. R. Fulton, pathologist at the experiment station. Meantime the discovery of the midge at Baton Rouge had been communicated to Mr. F. B. Headley, then superintendent of the San Antonio experiment farm, who immediately found the midges to be abundantly present in the sorghum plats at that point. Mr. Headley thereupon began a series of bagging experiments similar to that just mentioned. This series was continued and extended by the senior writer after his arrival at San Antonio.

From a study of plants in the field [3] it was soon found that eggs are sometimes deposited as soon as the uppermost spikelets appear above the collar of the leaf sheath and that egg laying continues until the end of flowering, and usually for a day or two later. From two to four days are commonly required for the complete emergence of a sorghum head from the boot or upper leaf sheath. The time depends partly on the length of the head in different varieties and partly on conditions affecting the rapidity of growth. Flowering

[1] Through the courtesy of Prof. Wilmon Newell, then secretary of the Louisiana Crop-Pest Commission, to whom and to whose assistants the senior writer is indebted for valuable help, he was given the free use of their entomological library and also of their laboratory and its equipment.

[2] Coquillet, D. W. Bulletin 18, n. s., Division of Entomology, U. S. Dept. of Agriculture, 1898, pp. 81–82.

[3] For a full discussion of the life history and habits of this insect, see the paper by W. Harper Dean, entitled "The Sorghum Midge," Bulletin 85, pt. 4, Bureau of Entomology, U. S. Dept. of Agriculture, May 23, 1910, pp. 39–58.

begins at the apex of the head, usually one or two days after its emergence, and progresses gradually downward to the base of the head. The flowering period for the entire head varies, therefore, from three to five or six days. The period during which midge infestation takes place is at least from two to four days longer than the flowering period.

In the bagging experiments a series of plants was selected, in duplicate, on which the heads represented every step in their development, from the emergence of the tip spikelets to a period three or four days after the end of flowering. The successive steps in development represented intervals of one day each. In one series the heads were protected by paper bags in the manner previously described; in the other series they were left without protection. In both series the selected plants were marked by tags carrying all necessary information as to date and condition of development at the time of bagging. The entire duplicate series was repeated in each of the four different varieties used in the planting test. The total number of heads under observation was 482, of which 315 were unprotected and 167 were bagged. With certain exceptions, noted later, the results were very uniform and conclusive. Heads protected as soon as the first spikelets appeared were uniformly and completely fertile; heads bagged at different stages of flowering were sterile as far as they had been in flower at the time of covering, but fertile in the lower and unflowered portions; heads bagged after flowering was past were uniformly and completely sterile; heads unprotected at any time were sterile (fig. 1). The exceptions to be noted are as follows:

(1) A few heads bagged while very young failed to develop normally, probably because of inherent weakness increased by inclusion within the bag. This occurred occasionally also in the series of heads not bagged.

(2) A few heads were infested with the larvæ of the corn worm, false army worm, etc. These usually molded badly inside the bags and did not produce seeds.

(3) In one or two cases a bagged head was infested by midges, which entered through very small holes accidentally made in the bags.

(4) At Baton Rouge the number of midges seemed to increase and diminish in periodic waves representing the appearance of successive broods of midges and the intervals between broods. There were two periods of five to seven days each when the midges were either very scarce or entirely absent. Checked heads exposed and in flower during these periods were only partially infested and were therefore only partially sterile.

Sterile heads examined at any time within 10 days after the date of full flower showed larvæ or pupæ of the midge inside their spikelets. No trace of the midge could ever be found in fertile spikelets. These data prove conclusively that sterility is due entirely to the infestation of the spikelet by the sorghum midge.

The further experiments conducted that season at Baton Rouge by Prof. Fulton and at San Antonio by Mr. Headley and the senior writer gave a very good working knowledge of the habits of the midge. The entire life history, from the laying of the egg to the appearance of the adult insect, occupies from 14 to 20 days. These facts refer to the conditions obtaining at those two points during the

FIG. 1.—A tenth-acre plat of Dwarf milo (No. 149) planted March 4; in flower May 19; not injured by the midge; yield, 32 bushels per acre. Photographed May 31, 1911.

months of July, August, and September, 1907, and have been confirmed by the experience of more recent years. Brood follows brood with great rapidity until late in the season. Scarcely a day passes in summer when adults are not to be seen engaged in egg laying in preparation for a future generation. The midge was found to be at work as early as June and as late as October at the points where experiments were conducted. Even the abundance of the chalcid parasite at Baton Rouge had no appreciable effect on the numbers of the midge. This parasite has not been observed at San Antonio.

EXPERIMENTS IN MIDGE RESISTANCE.

At the beginning of the experiments to discover the cause of sterility this condition was known to occur from North Carolina westward to Oklahoma and southward to the Gulf. In the lower part of this large area complete sterility was the rule. As previously stated, the insect was present throughout most of the season and apparently was not controlled by the abundant parasite. From the nature of the midge itself and of the injury caused by it there seemed no hope of controlling it by any method of poisoning or other artificial means. In view of these facts it was planned to begin a series of extensive experiments to determine the midge resistance of different sorghum varieties.

NATURE OF THE INJURY.

In order to understand the investigations looking toward the finding of a midge-resisting variety of sorghum, it is necessary to understand how sterility is caused. The adult female midge deposits her eggs inside the outer glumes or chaff of the spikelet and usually against the ovary itself. This is done by means of a long ovipositor. From one to several eggs may be deposited in the same spikelet, either by the same insect or by different insects. The injury resulting in sterility is inflicted by the larva. Its mouth parts are weak and not especially fitted for biting or sucking. It doubtless gets its nourishment in a manner similar to other closely related insects, notably the wheat midge (*Contarinia* (*Diplosis*) *tritici*) and the Hessian fly (*Mayetiola destructor*), the one affecting the ovaries and the other the stems of wheat.

An examination of the spikelets of infested sorghum discloses the larva lying in close contact with the walls of the shrunken ovary, from which it is absorbing the juices. In shrinking the ovary usually becomes distinctly concave on the side next the larva, which lies thus in a hole partially surrounded by the walls of the ovary. There is no breaking of the tissues of the ovary and no other signs of injury than the shrunken and occasionally discolored appearance. A single larva within the spikelet is sufficient to cause the death of the ovary.

VARIETIES TESTED IN 1909.

From the nature of the attack and the injury inflicted it was thought that varieties with very long glumes or with very short glumes might prove resistant. In the case of varieties with long glumes there was a chance that the egg would be deposited so far above the apex of the ovary as to make it impossible for the larva ever to reach the ovary. In the case of varieties having glumes much

shorter than the seeds it was hoped that the scanty protection afforded by the short glumes might result in the death of the egg or larva from the heat or drying action of the sun. There was also the possibility that the texture of the glumes in certain varieties might render infestation impossible except during the very short period in which the glumes are held wide apart by the swollen lodicules. Certain varieties of durra from India have two seeds in each spikelet. It was thought that as each spikelet is usually infested by only a single larva it would be possible that only one of the two seeds would be destroyed, the other being allowed to continue its growth. These twin-seeded varieties are not very desirable from the standpoint of grain production, but were considered worth trying for midge resistance.

Owing to unavoidable circumstances these experiments could not be undertaken at San Antonio until 1909. During 1908,[1] however, a large number of varieties were under observation at other points where midge infestation occurs regularly, but is usually only partial. These experiments showed that all varieties were affected to about the same degree wherever they were in flower when midges were present in numbers.

In 1909 the following varieties were tested for midge resistance at the San Antonio experiment farm under the immediate charge of the junior writer:

Milo: Dwarf (G. I. No. 149) and Standard (G. I. No. 231).
Durra: White (G. I. No. 81); Dagdi (G. I. No. 246); White Twinseed (G. I. No. 248); Buff Twinseed (G. I. No. 250).
Kafir: Blackhull (G. I. No. 207); Red (G. I. No. 34).
Kowliang: Barchet Blackhull (G. I. No. 310); Manchu Brown (G. I. No. 171).
Shallu: (G. I. No. 217).

In addition to these grain-producing varieties observations were made on several sorgo varieties grown for forage purposes.

RESULTS OBTAINED IN 1909.

The results in 1909 were on the whole very discouraging. Owing to the extremely dry season all varieties were badly injured by drought. The plants were not only much stunted, but many of them were badly burned and did not produce heads at all. In spite of the dry weather, which probably was unfavorable to midge development, all varieties except Sumac sorgo were largely sterile. The resistance of Sumac sorgo is probably due to the very short glumes, which are scarcely half as long as the small seeds, which in turn are smaller than those of

[1] At the request of the Bureau of Plant Industry a study of the sorghum midge from an entomological standpoint was begun at San Antonio by the Bureau of Entomology, represented by Mr. W. Harper Dean. A recent publication by Mr. Dean (The Sorghum Midge, Bulletin No. 85, pt. 4, 1909, revised edition, 1911) gives a rather complete description and history of the pest, with suggestions for measures to be taken to control it.

any other grain or forage variety. Unfortunately, even in the Sumac variety, with all these advantages, resistance is only partial, not enough to make profitable for grain production a variety no more resistant than this. The Twinseed durras from India were as badly injured as any of the others.

SEASONAL LIMITS OF MIDGE ACTIVITY.

So far as finding resistant varieties was concerned the experiment of 1909 was practically a total failure. There was not enough difference in the behavior of the different varieties to indicate that the problem could be solved in this manner. It was observed by the junior writer that some seed had set, and in nearly every instance this was either on the early ripening plantings or on those maturing late in the season. The plantings ripening in early June set a very much larger percentage of seed than those ripening later in the season. There were hardly enough data to conclude that by extremely early planting a crop could be matured with practically no midge damage, but this seemed possible.

It was not known definitely then that the adult midges coming from the "cocooned" or winter larvæ described by Dean are usually too few in number to cause wholesale sterility. It is only in June when the adults, from eggs laid by the first spring brood, begin to appear that severe infestation begins.

EXPERIMENTS IN MIDGE EVASION.

PRELIMINARY TESTS IN 1910.

The experimental work of 1907, 1908, and 1909 had demonstrated quite thoroughly that, so far as could be determined from these tests, no varieties of sorghum are immune to the attacks of the sorghum midge. The work for 1910 was planned, therefore, to determine whether it was possible by means of very early or very late planting to bring the blossoming period of any varieties at a time when midge infestation was normally at a minimum. Six grain sorghums, representing all the leading groups, were selected for the experiment. A larger series was impracticable on account of the series of successive plantings required and the comparatively small area available. The six varieties were milo (G. I. No. 77), Dwarf milo (G. I. No. 149), White durra (G. I. No. 27), Blackhull kafir (G. I. No. 71); Manchu Brown kowliang (G. I. No. 171–9), and shallu (G. I. No. 217). To these were added Amber, Red Amber, Sumac, and Gooseneck sorgos.

The plantings of these 10 varieties were begun in the latter part of February and continued at monthly intervals through June, making five plantings in all. Each variety was planted in a 4-rod row on each date.

The early varieties from the February planting came into flower in 60 to 70 days, or during the latter days of April and the first days of May. Later varieties flowered at different dates in May. The early varieties in the second or March planting were also in flower in the latter part of May. All the varieties in the first planting and all the early varieties in the second or March planting were thus in flower before the midge appeared in any abundance. Infestation was therefore slight and profitable yields were produced. All varieties which, by reason of later planting or late maturity, did not flower before the end of June were badly infested and gave very poor or no yields. In 1910 the emergence of the midge in numbers sufficient to seriously affect the heads was not until July, somewhat later than in 1909.

Unfortunately, the actual yields could not be determined for the high-yielding early varieties. They were planted in very small areas, only a 4-rod row of each variety on each date. Owing to the small areas, and perhaps also to the scarcity of other crops, the seeds were almost entirely taken by birds during the ripening process. Yields obtained on such small areas would not have been wholly reliable, even if none of the seed had been lost.

The main point had been to determine whether successful evasion of midge attacks would result from early planting. This point was most successfully proved by both the 1909 and the 1910 experiments.

An interesting fact resulted from a test of some forage sorgos under irrigation. It was found that if the first growth were cut for hay at about the time of heading, the second crop from stubble would come to flowering so late that but few midges were present and only slight infestation took place. In this way a fair crop of seed was produced quite late in the season. The growth of two crops a year in the San Antonio region will be possible, however, only with an early variety and under irrigation, ordinarily. A careful examination of the plat was made on October 15, when most of the heads were past flowering. A few midges were found at work on the heads, but when the heads ripened the estimated midge damage was not more than 2 per cent. The yield from this plat was at the rate of 15 bushels per acre.

EARLY PLANTING EXPERIMENTS IN 1911.

For the year 1911 the early plantings were continued on a scale large enough to avoid serious injury by the birds and to enable the yields to be accurately measured. Eleven grain-sorghum varieties were used and these were planted at three successive and comparatively early dates, namely, March 4, March 15, and April 1. The experiments of 1910 had proved clearly that plantings made later than April 1 were generally sure to be seriously injured by the midge unless the variety planted was very early in maturing. A

tenth-acre plat was devoted to each variety at each planting. (See figs. 1 and 3.)

Table IV contains the results of the experiments. It shows the variety, the dates of planting, of heading, and of ripening, the number of days between planting and heading, the yield per acre of thrashed grain, and the estimated damage through midge infestation. The facts obtained from each of the three dates of planting are tabulated separately.

TABLE IV.—*Results from successive early plantings of different grain sorghums at San Antonio, Tex., 1911.*

G. I. No.	Variety.	Date planted.	Date headed.	Time to head.	Stand.	Yield per acre.	Estimated injury by midge.[1]
	First planting:						
	Milo—			*Days.*	*Per cent.*	*Bushels.*	*Per cent.*
.....	Commercial	Mar. 4	May 19	76	85	26.5	0
234	Standard	...do...	...do...	76	90	31.2	0
149	Dwarf	...do...	...do...	76	90	32.0	0
	Durra—						
27	White	...do...	May 22	79	90	24.5	0
182	Sudan	...do...	May 24	81	70	25.3	0
	Kafir—						
207	Blackhull	...do...	May 26	83	95	16.0	5
340	Dwarf Blackhull	...do...	May 27	84	95	22.0	5
34	Red	...do...	June 6	94	95	12.2	5
	Kowliang—						
350	White	...do...	May 13	70	95	17.2	0
310	Barchet	...do...	May 29	86	95	25.0	0
171	Manchu	...do...	May 16	73	90	25.2	0
349	Shallu	...do...	May 27	84	95	20.7	0
	Average yield and injury					23.1	1.25
	Second planting:						
	Milo—						
234	Standard	Mar. 15	May 29	75	90	25.1	0
149	Dwarf	...do...	...do...	75	90	24.2	0
	Durra—						
27	White	...do...	...do...	75	95	17.3	10
182	Sudan	...do...	June 2	79	80	14.7	10
	Kafir—						
207	Blackhull	...do...	June 9[2]	86	95	3.6	25
340	Dwarf Blackhull	...do...	June 6	83	95	12.0	25
34	Red	...do...	June 17	94	95	2.2	20
	Kowliang—						
350	White	...do...	May 24	70	95	15.2	0
310	Barchet	...do...	June 8	85	95	11.2	35
171	Manchu	...do...	May 26	72	95	19.0	0
349	Shallu	...do...	June 12	89	95	7.8	[3]
	Average yield and injury					13.8	12.5
	Third planting:						
	Milo—						
234	Standard	Apr. 1	June 6	66	95	11.8	5
149	Dwarf	...do...	...do...	66	95	17.3	5
	Durra—						
27	White	...do...	June 9[2]	69	90	13.3	10
182	Sudan	...do...	June 14[2]	74	90	1.9	15
	Kafir—						
207	Blackhull	...do...	June 17	77	90	.9	80
340	Dwarf Blackhull	...do...	...do...	77	95	1.9	75
34	Red	...do...	June 21[2]	81	90	.4	50
	Kowliang—						
350	White	...do...	May 31	60	95	12.8	25
310	Barchet	...do...	June 14[2]	74	95	2.5	15
171	Manchu	...do...	June 3	63	95	5.3	.....
349	Shallu	...do...	June 23[2]	83	95	.8	[4]
	Average yield and injury					6.2	31.1

[1] The average injury is based on 12, 10, and 9 varieties, respectively, in the 3 plantings.
[2] Only the blooming date was recorded; the heading date was determined by subtracting 3 days.
[3] Comparatively little headed. A large percentage was sterile.
[4] Very poorly filled. It was impossible to determine the extent of the midge injury.

RESULTS OF EARLY PLANTINGS IN 1911.

The results obtained are strikingly clear cut and positive, completely confirming the earlier observations and experiments. Early planting had enabled the crop to escape midge injury. (Fig. 2.) The 12 lots in the first planting gave an average yield of 23.1 bushels per acre. Excluding the milo from commercial seed, which does not appear in the second and third plantings, the average yield was 22.8 bushels as compared with 13.8 bushels in the second

FIG. 2.—Heads of grain sorghums from the planting of March 4, showing absence of midge injury: *A*, Dwarf milo; *B*, Dwarf Blackhull kafir; *C*, Sudan durra. Photographed June 6, 1911.

planting and 6.2 bushels in the third planting. The yields from each variety in the three plantings are arranged in parallel columns in Table V to facilitate comparison.

Only part of the diminution of yield from the second and third plantings is properly chargeable to the midge, however. The other part is due to the increasing drought. This fact constitutes a strong additional argument in favor of early plantings, because summer droughts are of frequent occurrence and often seriously injure later

maturing crops. The proportionate injury by the midge and by drought in this case can be learned by comparing the percentage by which the yield was lowered with the recorded percentage of midge injury. The difference is the loss by drought. In the first planting the highest yielding variety was Dwarf milo (see fig. 1), with 32 bushels; the lowest, Red kafir, with 12.2 bushels. It is worth noting also that the Red kafir was the latest of the 12, being 10 days later in heading than any other variety.

Very little injury was done by the midge to the varieties in the first planting. An estimated damage of 5 per cent is recorded for each of the three kafirs. No injury was noted in any of the others, though the Barchet kowliang and shallu were in flower as late as the kafirs. The average midge injury on the entire 12 varieties of the first planting is only 1.2 per cent.

In the results of the second planting several facts stand out prominently. The average yield is much lower and the percentage of midge infection much higher than in the first planting. Four of the earlier varieties in this planting which flowered as early as the later varieties in the first planting entirely escaped injury. In spite of this the average yield of these four varieties in the second planting was only 20.9 bushels, while in the first planting it was 26.4 bushels, showing a decrease of about 20 per cent, apparently an effect of the drought on the later planting and certainly not due to the midge. The average yield per acre of the 11 varieties (the commercial milo not being grown) was 13.8 bushels, a decrease of 40 per cent from the same varieties in the first planting. The average midge injury for 10 varieties, omitting shallu, is 12.5 per cent, or just 10 times that of the first planting. If shallu had been included the percentage would be much higher, probably reaching 18 or 20 per cent.

The average midge damage for the last planting was 31.1 per cent, omitting the last two varieties, or about two and one-half times that of the second planting and nearly thirty times that of the first planting. This shows very strikingly that planting as late as April 1 is extremely precarious unless very early maturing varieties are used. As the climate is such that even cotton is planted earlier than the date mentioned, a late planting is entirely unnecessary as well as unprofitable.

The search for midges in the field was begun on May 15, when the earliest variety in the first planting, Manchu kowliang, was

about to head. The plats of sorghum were whipped with an ordinary insect net on different dates, with the following results:

May 15. Two midges taken from two rows.
May 16. Do.
May 19. Do.
May 22. None found.
May 25. Do.
May 29. Do.
May 31. Do.
June 3. One midge taken.
June 12. A number of midges taken and several observed at work on the heads.
June 17. Midges very plentiful; large numbers observed working on the heads.

It will be noted that after taking a very limited number of midges just past the middle of May no more were found until well along in June, when they became abundant (about June 10 or 12). The few observed in May were doubtless the result of overwintering in waste sorghum or Johnson grass, and the large numbers appearing 20 to 25 days later were as certainly their progeny. By reference to Table IV it will be seen that all but one of the varieties of the first planting were past flowering by June 1 and that little or no injury resulted from the appearance of the midge early in June. The earliest varieties in the second planting were also nearly past flowering in late May and were only slightly injured. All the later varieties in the second planting and all varieties in the third planting flowered after the first week in June and were badly infested. (Fig. 3.)

RESULTS OF JUNE PLANTING IN 1911.

On June 16 three varieties, Dwarf milo, Sudan durra, and shallu, were planted where they could be irrigated. The first two doubtless headed in August and the shallu early in September, but owing to the absence of both the writers no notes regarding the date of flowering, abundance of the midge, etc., were taken. When an examination was made on September 13 midges were found in large numbers working on the late heads still flowering, the greater part of the heads on all the varieties being mature. The injury to Dwarf milo and Sudan durra was estimated at fully 95 per cent. Shallu was not so far advanced, but the damage did not appear to be nearly as great as on the first two varieties named. The midges did not appear to be as plentiful on the heads of shallu as on the late-flowering heads of the durra and milo.

YIELDS OF GRAIN SORGHUMS, OATS, AND CORN IN 1911.

In connection with the grain-sorghum yields it is of interest to give the oat and corn yields for 1911. The average yield from the rotation plats of oats was 8.4 bushels per acre and of corn 10.2

bushels. The yield from the best plat of oats was 15.6 bushels and from the best plat of corn 19.6 bushels. The average yield from the first planting of sorghums was 23.1 bushels, 14.7 bushels better than the average yield of oats and 12.9 bushels better than the average yield of corn. The best plat of grain sorghum, a Dwarf milo (see fig. 1), gave a yield of 32 bushels per acre, or 16.4 bushels more

FIG. 3.—Heads of Sudan durra (G. I. No. 182): *A*, In flower the latter part of May, not injured by midge; *B*, In flower about September 1, almost entirely sterile. Photographed September 15, 1911.

than the best plat of oats and 12.4 bushels more than the best plat of corn. These figures are particularly significant, as they compare the yielding power of the grain sorghums with the grain crops most commonly grown and heretofore considered the best for the San Antonio region.

SUPPLEMENTARY METHODS OF CONTROL.

The habits of the insect and the nature of its attack seem to exclude the possibility that any artificial remedy can be used. Each

spring the crop of midges starts anew from specially enveloped or "cocooned" larvæ,[1] which hibernate through the winter in the heads of sorghums and Johnson grass in fields, fence rows, waste grounds, and even in stacks. The complete clearing of the crop from the fields, the destruction of all scattered stalks in odd places, and the burning of Johnson grass where possible will undoubtedly aid in reducing the number of larvæ living over winter and thereby delay the appearance of destructive numbers in early summer. It is possible that the adults do not fly very far, and that fields may be protected in great measure by destroying the breeding places.

DISTRIBUTION OF THE SORGHUM MIDGE.

It is now known that the midge occurs as far west in Texas as Uvalde, San Angelo, and Chillicothe, but is not usually seriously destructive at these points. Northward it occurs across Oklahoma to central Kansas and eastward to North Carolina and Georgia. It is most destructive in the southern part of its range or near the Gulf coast.

Examined fields in the vicinity of San Antonio have all proved to be infested and the midge has been reported both east and south of San Antonio, as far as Brownsville, although the damage appears to be more severe near San Antonio than in most other areas in Texas. Yields reported by farmers between San Antonio and Brownsville indicate that there are breaks in the areas infested between these points.

INJURY DONE BY BIRDS.

Some doubt has been expressed regarding the possibility of growing grain sorghums in this section because of the injury done to the crop by birds. While it is to be expected that these pests will continue to be in evidence, yet when large areas are devoted to the crop it is doubtful whether much damage will be done. The cause of so much damage being done at the present time is that only small isolated areas are planted and the birds gather from a considerable area to feed on these fields. In the test made in 1911 it was found necessary to hire a boy to keep the birds off the plats, in order that reliable yields could be obtained.

CULTURE OF GRAIN SORGHUMS.

Since it has been shown that these crops can be profitably grown it is desirable to discuss the best varieties for the region and to give brief directions for growing them.

[1] Dean, W. H. Loc. cit.

BEST VARIETIES FOR THE REGION.

As has been clearly shown, other qualities being equal, an early maturing variety is most desirable and should be selected for planting. In Table V are shown the comparative yields of the early and the late varieties in the three plantings of 1911. The number of days required from planting to heading are also given for each variety. These data are all adapted from Table IV. The varieties that appeared to be the most desirable in 1911 were the Dwarf milo (see fig. 1), Standard milo, and Sudan durra (see fig. 4). In the case of all three plantings the early varieties produced markedly better yields.

TABLE V.—*Comparative yields, in bushels per acre, of early and late varieties of grain sorghum, arranged in the order of earliness.*

Varieties.	Time to head.	First planting.	Second planting.	Third planting.
	Days.	*Bushels.*	*Bushels.*	*Bushels.*
Kowliang, White	70	17.2	15.2	12.8
Kowliang, Manchu	73	25.2	19.0	5.3
Milo, Standard	76	31.2	25.1	11.8
Milo, Dwarf	76	32.0	24.2	17.3
Durra, White	79	24.5	17.3	13.3
Average yield of five earliest varieties		26.0	20.2	12.1
Durra, Sudan	81	25.3	14.7	1.9
Kafir, Dwarf Blackhull	84	22.0	12.0	1.9
Kafir, Blackhull	84	16.0	3.6	.9
Shallu	84	20.7	7.8	.8
Kowliang, Barchet	86	25.0	11.2	2.5
Kafir, Red	94	12.2	2.2	.4
Average yield of six later varieties		20.2	8.6	1.4

Table V shows very clearly the effect of early maturity on the yields of the late plantings, especially that of April 1. The yields for the five early varieties of that planting averaged 12.1 bushels, while that of the six later varieties averaged only 1.4 bushels. While the drought is an important factor and no doubt influenced the yields as much as did the midge, yet it is none the less interesting, as it emphasizes the importance of planting early-maturing varieties as well as of early planting. Productiveness is of importance and should have weight in the selection. Under more favorable conditions as to the moisture supply, some of the kafirs, especially the Dwarf Blackhull kafir (fig. 2, *b*), may prove equal to or better than those previously named. More data will have to be obtained before definite recommendations can be made, although either of the three named can be safely grown with the expectation of securing a good crop.

PREPARING THE SEED BED.

As has been shown in the preceding pages, the production of grain sorghums, in spite of the ravages of the midge, has been made possible by the selection of early-maturing varieties and by early planting. Having demonstrated the importance of these points, the next thought is the preparation of the seed bed. While earliness is largely dependent upon the planting of quick-maturing varieties, yet it is also important to prepare the seed bed thoroughly. This means a rapid, uniform germination and strong, vigorous plants, which will be uniformly earlier than the plants on a poorly prepared seed bed.

FIG. 4.—A tenth-acre plat of Sudan durra (G. I. No. 182) planted March 4; in flower May 24, not injured by the midge; yield, 25.3 bushels per acre. Photographed June 2, 1911.

Fall plowing is essential to obtain the best results, for by so doing a greater part of the late fall and winter rains are saved than would otherwise be the case. The seed bed is also in a better condition at planting time on fall-plowed land, promising a quicker and more uniform germination. If the ground is harrowed occasionally, the additional expense will be well worth while, as a better seed bed will result and in addition the moisture will be conserved.

DIRECTIONS FOR PLANTING.

TIME OF PLANTING.

The experiments so far carried on indicate that planting should be done as near March 1 as possible. While there is some danger of a frost injuring or even killing the crop, making it necessary to

replant, a review of the frost records shows that the risk is not great enough to make later planting seem advisable if maximum yields are expected.

The importance of having an uninterrupted growth from planting until maturity can not be too strongly emphasized, and for this reason extremely early planting is inadvisable. The growth is liable to be interrupted either by a long-continued cold spell or by frost from which the crop may not fully recover. The chances for securing an uninterrupted growth from a crop planted in a well-prepared seed bed and reasonably early are much better than where these points are disregarded.

Aside from evading the injury of the midge, early planting will escape to some extent the drought which is liable to occur during the hot months of the year. While the rainfall during the months of June and July averages about as high as for the remainder of the year, the evaporation is so much higher that less of the rain actually is utilized in plant growth than during the earlier months.

METHOD OF PLANTING.

The method adopted in these experiments was to have the rows 4 feet apart and the plants about 5 inches apart in the row. The crops were planted with a combined cotton and corn planter equipped with the small plates used in sorghum planting, with the holes drilled so that one or two seeds were planted about every 3 or 4 inches. The stand was later thinned to single plants about 8 inches apart. This rate of planting will not require more than 6 pounds of seed per acre and a thinner rate of seeding may prove desirable, as the plants stool very profusely. A recent publication[1] gives the following suggestions:

> The results of four years' experiments at the Amarillo experiment farm, Texas, indicate that in general the kowliangs yield best with a stand of 1 stalk in each 5 or 6 inches of row; the milos and durras with 1 stalk in each 7 or 8 inches of row; and the kafirs with 1 stalk to each 9 or 10 inches of row. The rows are always 3½ feet apart and, as far as possible, the seeds are dropped singly in the rows. Under these conditions improved varieties in each of these three distinct groups give approximately the same yields. The Amarillo experiment farm has an elevation of 3,600 feet and an average annual rainfall of 22 inches, the larger part of which comes during the growing season. Further investigation, continuing the experiments through a longer period of years, may discover that better average yields will be produced at other spacings than those noted above.

The only variation from the ordinary method was to attach to each shoe of the planter two wings, which were modified sweeps. These sweeps were so placed that the bottom of the shoe was 2½

[1] Ball, Carleton R. The Importance and Improvement of the Grain Sorghums. Bulletin 203, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, p. 35.

inches from the lower side of the two wings. By adjusting the lever regulating the depth, the seed was buried in the moist soil to a uniform depth, no matter what the depth of the mulch. A rapid and unusually good germination resulted.

FEEDING VALUE.

The senior writer has previously cited experiments at several State experiment stations[1] to show that the feeding value of Blackhull kafir is but little below that of corn. From analyses published therein it was found that grain-sorghum kernels "averaged a little higher in protein content and a little lower in ether extract or fat and in fiber." These facts answer the question so often brought forward by farmers as to the feeding value of the grain. Its principal use in the San Antonio region has been for poultry food, but there is no reason why there should not be a greater demand for it as stock food.

SUMMARY.

A profitable grain crop for feeding purposes is much needed in the region discussed. Neither small grains nor corn can be depended upon for profitable crops.

Grain sorghums are fully adapted to the region, but have wholly failed to set seed, a condition popularly known as blast and usually believed to be due to excessive rainfall at blooming time.

Cooperative experiments conducted at Baton Rouge, La., and San Antonio, Tex., in 1907 rediscovered the sorghum midge and proved conclusively that it is the cause of sterility in sorghums.

The midge is normally present in abundance from June to September and in smaller numbers both earlier and later in the season, but not sufficient, however, to do much damage.

The eggs are laid inside the glumes, or hulls, on or near the ovary or undeveloped seed. The worm or larva, hatching from the egg, lies against the ovary and probably absorbs its juices through the body walls, causing the ovary to shrivel and dry.

The midge passes through all stages from the egg to the adult in 14 to 20 days in the summer. This short life cycle insures plenty of midges most of the time. More than 1,000 have been hatched from a single head of sorghum.

Observations and experiments in 1908 and 1909 failed to find midge-resistant sorghums in any group.

Experiments in 1910 showed that by early planting varieties could be brought to the blooming stage before the midge became sufficiently abundant to cause much injury. No definite yields were obtained,

[1] Ball, C. R. Op. cit., pp. 12–13.

because the plats were very small and most of the grain was taken by birds before fully ripe, except that on a plat of Sumac sorgo ripening in October.

Experiments conducted in 1911 on a larger scale with 11 varieties of grain sorghums proved conclusively that profitable yields can be had from early plantings. The average yield of all varieties planted on March 4 was 23.1 bushels and of the best early variety 32 bushels per acre. Corn on similar land in the same season yielded an average of 10 bushels per acre.

Early varieties planted on March 15 made good yields; the later varieties, poorer yields. Varieties planted as late as April 1 were unprofitable because of midge injury and drought.

The midge overwinters in sorghum and Johnson grass left in fields and fence corners, waste places, etc. By destroying all such breeding places about the farm during the winter the appearance of large numbers of midges in early summer can be delayed, giving the crops a better chance to flower without infestation.

Experiments show that early varieties are the highest yielders and the most profitable, not only because they most surely evade midge injury, but because they also more fully escape summer drought. Milo and Dwarf milo, Manchu kowliang, and White durra are the earliest varieties. Sudan durra and Dwarf kafir are also promising.

Fall plowing is desirable to conserve moisture. A thorough preparation of the seed bed is essential to prompt and uniform germination.

Planting should be done as near March 1 as possible, to insure flowering before midges become abundant. The risk from late spring frosts is not great enough to offset the added risk of midge and drought injury in the case of later planting.

Grain sorghums should be planted in rows about 3½ feet apart. One stalk every 5 or 6 inches in the row is about the right space for kowliang, every 6 to 8 inches for milos and durras, and every 8 or 10 inches for kafirs. These rates will require about 3 to 5 pounds of seed per acre.

In feeding value the grain sorghums rank somewhat lower than corn. Analyses show the kernels to average a little higher in protein and a little lower in fat and in fiber than those of corn.

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